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A COST COMPARISON OF HIGH AND LOW CEILINGS IN MODERN GROCERY WAREHOUSES

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PREFACE

This study was conducted under the general direction of R. W. Hoecker, assistant director of the former Transportation and Facilities Research Division, Agricultural Research Service. This type of research is being continued under the auspices of the Food Distribution Research Laboratory, Agricultural Marketing Research Institute, Beltsville, Md.

Acknowledgment is due Associated Food Stores, Inc., Salt Lake City, Utah; and Giant Food, Inc., Landover, Md., whose management provided facilities and data for the study. Also deserving special mention are Glen R. Johnson, Jr. Clark Equipment Co., Battle Creek, Mich.; and William A. Webb, Rolf Jensen and Associates, Inc.--Fire Protection Engineers and Building Code Consultants, Northfield, Ill., who provided much valuable data and other helpful information.

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A COST COMPARISON OF HIGH AND LOW CEILINGS IN MODERN GROCERY WAREHOUSES

By Jack L. Runyan [1]

SUMMARY

The total initial costs of total warehouse space amounted to $0.49 per cubic foot for the high-ceiling facility (32-foot ceiling), and $0.56 per cubic foot for the low-ceiling facility (25-foot ceiling). Total initial costs of net, usable storage space amounted to $2.37 per cubic foot for the high-ceiling, and $2.71 per cubic foot for the low-ceiling facility.

Forklift operating time required to fill selection slots and to place incoming products in storage was 10,075 and 12,483 hours per year, respectively, for the high-ceiling and the low-ceiling facilities. Because less forklift operating time was required in the high-ceiling facility, the forklift operation cost $10,813 per year less than in the low-ceiling facility.

The results of comparing the annual ownership and operating costs for both grocery warehouses showed that in the high-ceiling facility, it cost $5.80 less per 1,000 cases shipped per year ($38.40 compared with $32.60) than in the low-ceiling facility.

Results of this study indicate that managers and owners of low-ceiling grocery warehouses especially should carefully compare costs with those for a high-ceiling facility before deciding on the most desirable ceiling height for a new building.

INTRODUCTION

One of the problems that confront managers and owners who are planning a new warehouse is determining what height ceiling to build. Managers can alleviate their problems by studying research results in which costs are compared for owning and operating grocery warehouses that have various ceiling heights. Although many costs in this study are subject to locational differences, their analysis should have wide application.

Studies were conducted of operations in two grocery warehouses. One had a 32-foot ceiling height (high-ceiling facility), and the other a 25-foot ceiling height (low-ceiling facility). The high-ceiling facility was owned and operated by a large, cooperative group food wholesaler, while the low-ceiling facility was owned and operated by a corporate chain. Data obtained from studies conducted in the two facilities and from secondary sources of information were used to simulate the cost data used.

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The term "stacking height" is often used to describe the functional height of a grocery warehouse. Literally, the stacking height is the maximum height to which products can be safely and conveniently stacked. Usually, products are stacked up to 4 feet from the ceiling. The open space between the top of the stack and the ceiling is necessary for ceiling supports (which are generally 1 foot thick) and for sprinkler clearance (which requires a 3-foot clearance). In the two warehouse facilities used as examples in this study, products were stacked in the high-ceiling facility to a height of 28 feet (32 feet minus 4 feet), and in the low-ceiling facility to 21 feet (25 feet minus 4 feet).

The overall objective of this study was to compare the cost of owning and operating a high-ceiling as opposed to a low-ceiling dry grocery warehouse. More specifically, the objectives of the study may be summarized as follows:

1. To gather and isolate cost information for a high-ceiling grocery warehouse.

2. To gather and isolate cost information for a low-ceiling grocery warehouse.

3. To apply the data obtained in objectives 1 and 2 to simulate a high-ceiling and low-ceiling grocery warehouse in order to develop comparisons of total and annual costs.

Data for the high-ceiling and the low-ceiling facilities were obtained by interviewing the distribution managers and other members of the administrative staffs of a large cooperative group food wholesaler and a local corporate food chain, and by making detailed time studies of their operations.

Most data used to compare the two types of facilities were simulated from the data obtained. To validly compare these facilities, the following assumptions were made:

1. Volume, product mix, length of selection lines, and the number and type of pallet racks were identical in both. However, adjustments were made to reflect the weight reduction in holding requirements in the low-ceiling facility.

2. Both warehouses were constructed of the same type of building materials.

3. Reserve storage in the low-ceiling facility was placed in floor stacks (pallet loads stacked without the use of pallet racks) parallel to the pallet racks.

Construction, equipment, and operating costs were obtained from manufacturers, financial institutions, public utilities, and from secondary sources. Labor costs were obtained from both the primary cooperators and from secondary sources. Labor requirements for forklift operations were determined by conducting time studies.

After the data were collected and the simulations completed, cost comparisons were developed. These cost comparisons and the conclusions from analyzing these data form the basis for this report.

DESCRIPTION OF FACILITIES, EQUIPMENT, AND OPERATIONS

Facilities were simulated for the cost comparisons from data obtained from studies conducted in a high-ceiling and a low-ceiling grocery warehouse. Ideas concerning layouts and equipment requirements were discussed with experts from the Food Distribution Research Laboratory, Agricultural Marketing Research Institute, ARS, and with technical employees of local public utilities, equipment manufacturers, and various consultants.

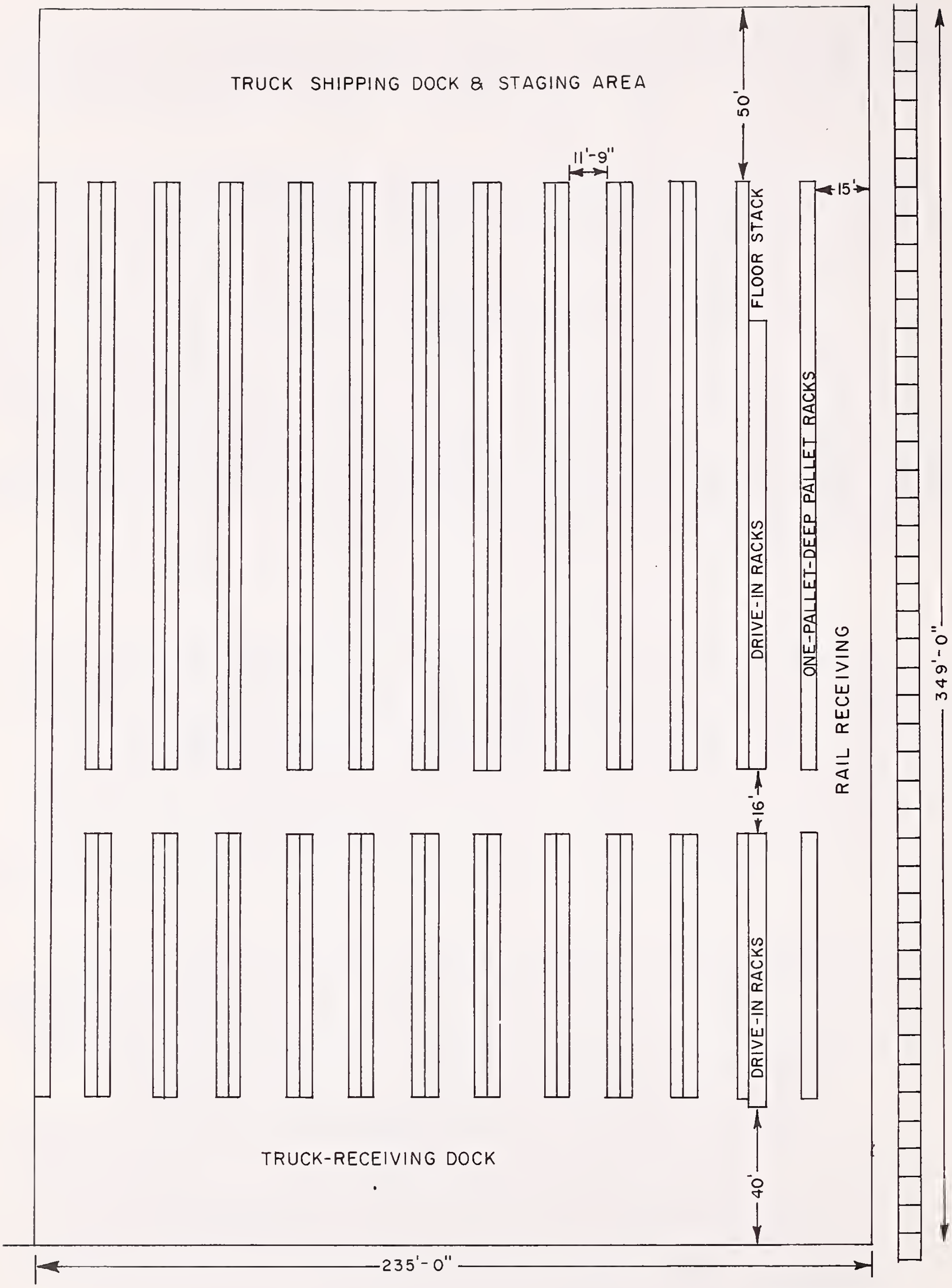
High-Ceiling Facility

It was estimated that the high-ceiling facility (fig. 1) would require 82,015 square feet (235 feet wide by 349 feet long) of floor space to handle approximately 7 million cases annually of grocery and grocery-related products. The aisle widths (11.75 feet) used in this warehouse were assumed to be adequate for the high-stacking forklift trucks. The width of a high-ceiling facility may vary, depending on the aisle widths required to provide space for forklift operations and for the use of other types of equipment needed.

Equipment

It was assumed that two types of pallet racks--conventional and drive-in--were used in the high-ceiling facility. The conventional racks are shown in figure 2. The bay space between uprights in each conventional rack is 108 inches wide by 36 inches deep. The bay space is able to hold either two large pallets (48 by 40 inches) lengthwise or three small pallets (40 by 32 inches) widthwise (fig. 3).

To use the method of stock placement shown in figure 3, large pallets must be placed in the pallet rack with the stringer (a 2- by 4-inch board to which the top and bottom boards have been nailed) facing out. Besides the conventional pallet racks shown in figure 3, there were assumed to be 43 drive-in racks that have bays capable of holding two large pallets placed end to end (lengthwise), rather than side by side (widthwise), as in the conventional pallet racks.



DRAWN TO SCALE

Figure 1.--Layout of the high-ceiling facility.

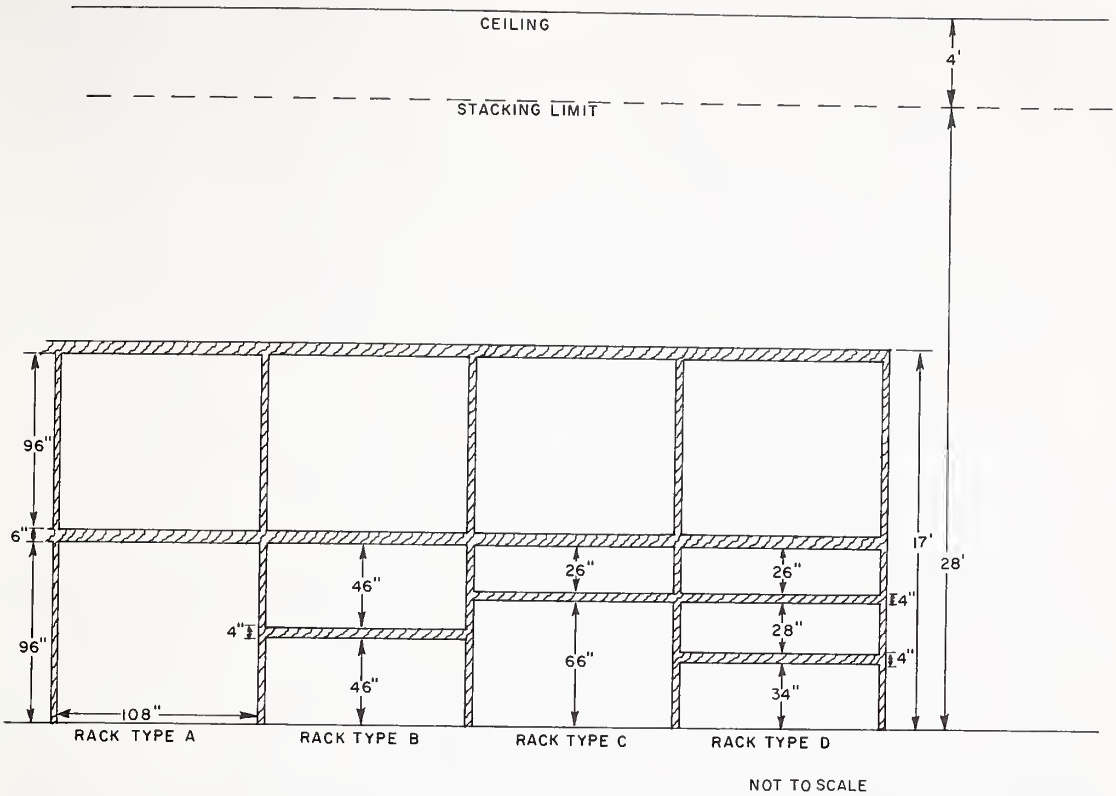


Figure 2.--Types of conventional pallet racks used in high-ceiling facilities.

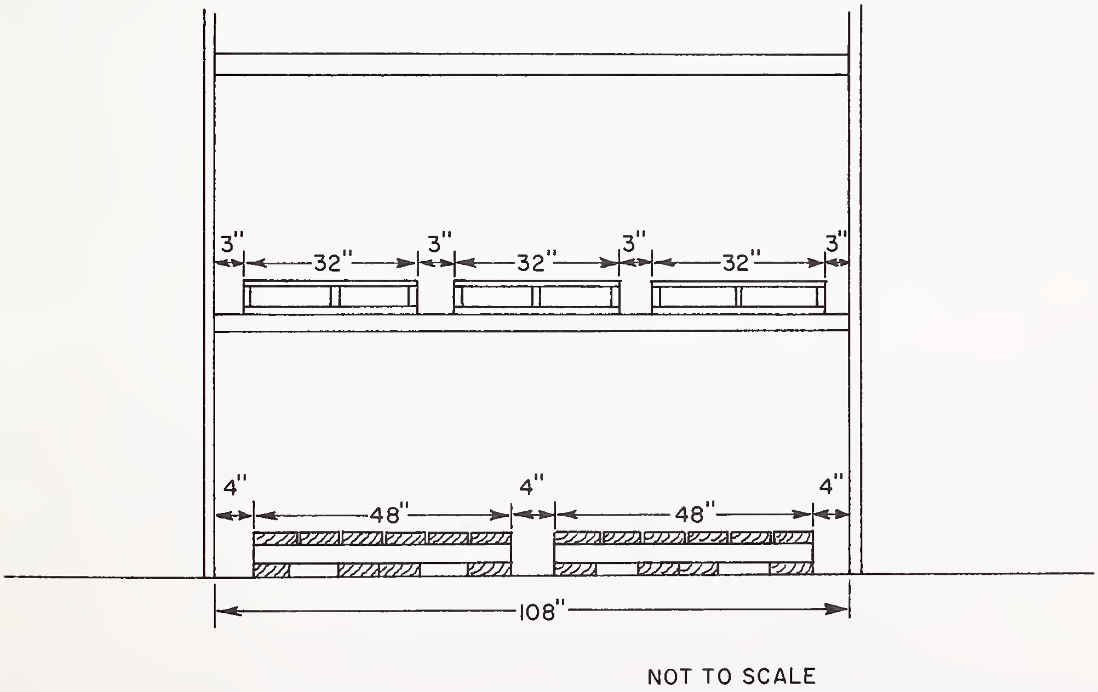


Figure 3.--Placement of large and small pallets in conventional pallet racks with 108-inch openings.

In the high-ceiling facility, it was estimated that six battery-powered, high-stacking lift trucks would be used to handle pallet loads of merchandise. It was assumed that the high-stacking lift trucks had three-mast stages (a mast is the housing on which the forks travel up and down). These trucks were used to move pallet loads of incoming products from the receiving areas and place them into the pallet racks, as well as to transfer pallet loads of products from rack reserve storage to the order selection areas.

Operators of the high-stacking lift trucks worked in assigned aisles (an average of three aisles per lift truck). They were responsible for moving pallet loads of merchandise from receiving docks and placing them into storage racks, and for stocking the order selection areas in their assigned aisles.

Battery-powered pallet jacks were used to select and transport customers' orders that were to be shipped on pallets in trucks. Carts pulled by battery-powered tuggers were used to select and transport orders that were to be hand-stacked in trucks.

Most warehousing operations, with the exception of truck unloading, were based on three shifts that averaged 7½ hours of work each.

Low-Ceiling Facility

It was estimated that the simulated low-ceiling facility (see fig. 4 for layout) would require 107,492 square feet of floorspace (308 feet by 349 feet) to handle the same volume of products handled in the high-ceiling facility. The layouts of the two facilities are the same, with one exception: 73 feet were added to the width of the low-ceiling facility to accommodate the following: four more aisles; two two-pallet-deep floor stacks; and four one-pallet-deep floor stacks.

Because of the increased width, the low-ceiling facility had 25,477 square feet more floorspace (approximately 34 percent more) than the high-ceiling facility. The additional floorspace, added to the low-ceiling facility to accommodate floor stacks for reserve storage, compensates for the reserve storage space above a 21-foot height in the high-ceiling facility.

Equipment

It was assumed that the same number and types of pallet racks were used in both facilities (see fig. 2). Pallet rack braces were changed to reflect reduced weight-holding requirements in the low-ceiling facility. Six conventional, battery-powered lift trucks were assumed to be sufficient to handle the workload in both facilities.

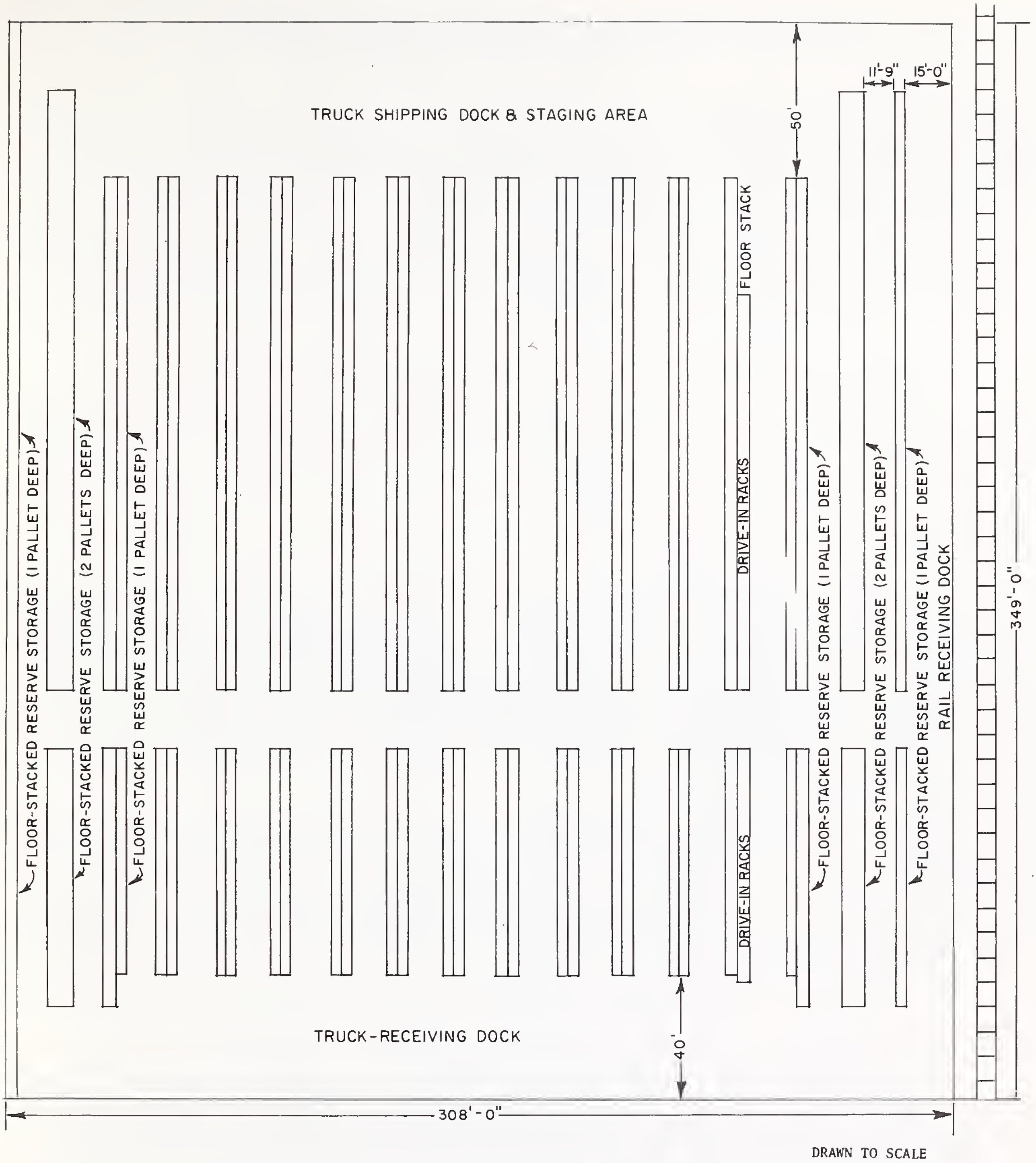

TRUCK SHIPPING DOCK & STAGING AREA
50'
11'-9"
15'-0"
FLOOR STACK
DRIVE-IN RACKS
DRIVE-IN RACKS
FLOOR-STACKED RESERVE STORAGE (1 PALLET DEEP)
FLOOR-STACKED RESERVE STORAGE (2 PALLETS DEEP)
FLOOR-STACKED RESERVE STORAGE (1 PALLET DEEP)
FLOOR-STACKED RESERVE STORAGE (1 PALLET DEEP)
FLOOR-STACKED RESERVE STORAGE (2 PALLETS DEEP)
FLOOR-STACKED RESERVE STORAGE (1 PALLET DEEP)
RAIL RECEIVING DOCK
349'-0"
TRUCK-RECEIVING DOCK
40'
308'-0"
DRAWN TO SCALE

Figure 4.--Layout of the low-ceiling facility.

Operations

Other than having floor-stacked reserve storage in the low-ceiling facility, operations in both facilities were assumed to be identical.

COMPARISON OF INITIAL INVESTMENT, ANNUAL OWNERSHIP, AND ANNUAL OPERATING COSTS

Initial investment, annual ownership, and annual operating costs must all be considered when planning a new facility. Management needs to know initial costs in order to determine the required cash outlay for land, construction, and equipment in the proposed facility and to estimate annual ownership costs. Management also needs to know annual ownership and operating costs in order to determine the fixed cost commitments for the new facility and to estimate the potential profitability or return on its investment.

Initial Investment Costs: Land, Construction, and Equipment

Each initial cost category (land, construction, and equipment) for the two warehouse facilities was estimated (table 1), and each will be discussed separately.

Land Costs

Initial land costs (table 1) include the actual building site and space for trucking operations and rail sidings. For both facilities, the land required for the building site was the actual space occupied by the building and was equal to the square footage of the building itself. The land required for the trucking area for both facilities was estimated to be 140 feet long and 235 feet wide (the same width as the high-ceiling facility). The land required for the rail siding area was estimated to be 19 feet wide and 349 feet long (the length of both facilities).

Total estimated land costs amounted to $75,124 for the high-ceiling and $87,862 for the low-ceiling facility--a difference of $12,738 in favor of the high-ceiling facility. Land costs are often given as a primary reason for justifying building facilities with high ceilings; however, in the two facilities used for this cost comparison, differences in construction costs are much more substantial.

Construction Costs

Construction costs included the costs for erecting the building, paving the trucking operations area, and installing the rail siding. Total estimated construction costs amounted to $890,705 for the high-ceiling facility and $1,120,870 for the low-ceiling facility--a difference of $230,165 in favor of the high-ceiling facility. Since the cost of the paving and rail siding for both facilities was the same, the estimated cost for erecting the high-ceiling facility was $230,165 less than for the low-ceiling facility (1,074,920 - $844,755), although the high-ceiling facility cost $0.30 more per square foot to erect (table 1, footnote 2) because of the greater height of the building.

TABLE 1.--Estimated initial land, construction, and equipment costs for a high-ceiling and low-ceiling grocery warehouse

Item	Cost of high-ceiling facility	Cost of low-ceiling facility	Savings with high-ceiling facility
	Dollars	Dollars	Dollars
Land: 1/			
Building site	41,008	53,746	12,738
Trucking operations area	30,800	30,800	0
Rail siding area	3,316	3,316	0
Total	75,124	87,862	12,738
Construction:			
Building 2/	844,755	1,074,920	230,165
Paving 3/	41,064	41,064	0
Rail siding 4/	4,886	4,886	0
Total	890,705	1,120,870	230,165
Equipment:			
Sprinklers 5/	93,199	83,492	-9,707
Lighting 6/	13,260	18,360	5,100
Pallet racks 7/	104,737	94,317	-10,420
Lift trucks 8/	109,470	99,420	-10,050
Total	320,666	295,589	-25,077
Grand total	1,286,495	1,504,321	217,826

1/ Based on an estimated cost of $0.50 per square foot.

2/ Based on an estimated cost of $10.30 per square foot for the high ceiling and $10 per square foot for the low-ceiling facility.

3/ Based on an estimated cost of $6 per square yard.

4/ Based on an estimated cost of $14 per linear foot.

5/ Based on estimates provided by a fire protection consulting firm.

6/ Based on estimates of a lighting engineer.

7/ Based on estimated cost FOB New Jersey.

8/ Based on estimated cost FOB Michigan.

Equipment Costs

Equipment costs included the sprinkler system, lighting fixtures, pallet racks, and forklift trucks in both facilities. If there had been a difference in order selection--either more or longer selection aisles--the cost for equipment used would also have been included.

Total estimated equipment costs amounted to $320,666 for the high-ceiling facility and $295,589 for the low-ceiling facility--a difference of $25,077 in favor of the low-ceiling facility. Equipment costs were higher for the high-ceiling facility because of the one additional level of sprinklers, the stronger pallet racks, and the more expensive forklift trucks needed.

Total Initial Costs

The estimated total initial costs amounted to $1,286,495 for the high-ceiling facility and $1,504,321 for the low-ceiling facility--a difference of $217,826 in favor of the high-ceiling facility (table 1). For further analysis, the total costs have been divided into (1) cost per square foot of total space, (2) cost per square foot of net usable storage space, (3) cost per cubic foot of total space, and (4) cost per cubic foot of net usable storage space (table 2).

As shown in table 2, the costs per square foot of total space and of net usable storage space for the low-ceiling facility ($14.00 and $56.97, respectively) are lower than for the high-ceiling facility (15.69 and $66.33, respectively). However, the cost per cubic foot of total space and of net usable storage space for the low-ceiling facility($0.56 and $2.71, respectively) are higher than for the high-ceiling facility ($0.49 and $2.37, respectively).

Annual Ownership Costs

Annual ownership costs--depreciation, interest, repairs, taxes, and insurance--represent expenses that are not influenced by fluctuations in product movement.

The estimated annual ownership costs for the two grocery warehouses are shown in table 3. The total estimated annual ownership costs amounted to $184,238 and $214,769, respectively, for the high-ceiling and the low-ceiling facility--a difference of $30,531 in favor of the high-ceiling facility. When costs were compared on a basis of 1,000 cases shipped, the total estimated annual ownership costs amounted to $25.90 and $30.20, respectively, for the high-ceiling and the low-ceiling facility--a difference of $4.30 in favor of the high-ceiling facility.

TABLE 2.--Estimated total initial costs per square foot and per cubic foot of total space and per net usable storage space for a high-ceiling and a low-ceiling grocery warehouse

Item	Cost of high-ceiling facility	Cost of low-ceiling facility	Savings with high-ceiling facility
	Dollars	Dollars	Dollars
Total land, construction, and equipment 1/	1,286,495	1,504,321	217,826
Per square foot of total space 2/	15.69	14.00	-1.69
Per square foot of net usable storage space 3/	66.33	56.97	-9.36
Per cubic foot of total space 4/	.49	.56	.07
Per cubic foot of net usable storage space 5/	2.37	2.71	.34

1/ Total initial costs from table 1.

2/ Based on 82,015 and 107,492 square feet, respectively, for the high-ceiling and low-ceiling warehouse.

3/ Total square feet less square footage of aisles, rail, and truck docks.

4/ Total square feet of floorspace in each warehouse multipled by the ceiling height.

5/ Total square feet of net usable storage space in each warehouse multiplied by 28 and 21 feet of stacking height, respectively, for the high-ceiling and low-ceiling warehouse.

TABLE 3.--Estimated annual ownership costs for a high-ceiling and a low-ceiling grocery warehouse

Item	Cost with high-ceiling facility	Cost with low-ceiling facility	Savings with high-ceiling facility
	Dollars	Dollars	Dollars
Depreciation: 1/			
Building 2/	28,159	35,831	7,672
Paving 3/	4,106	4,106	0
Rail track 2/	163	163	0
Sprinkler system 2/	3,107	2,783	-324
Lighting equipment 2/	442	612	170
Pallet racks 3/	10,474	9,432	-1,042
Lift trucks 4/	15,642	14,208	-1,434
Total	62,093	67,135	5,042
Interest: 5/			
Land	2,956	3,465	509
Building	33,790	42,997	9,207
Paving	1,642	1,642	0
Rail track	195	195	0
Sprinkler system	3,728	3,340	-388
Lighting equipment	530	734	204
Pallet racks	4,189	3,773	-416
Lift trucks	4,416	3,936	-480
Total	51,446	60,082	8,636
Repairs:			
Building & related 6/	7,379	9,033	1,654
Lighting equipment 7/	237	328	91
Pallet racks 8/	262	236	-26
Lift trucks 9/	1,642	1,491	-151
Total	9,520	11,088	1,568
Taxes:			
Real estate 10/	57,768	72,342	14,574
Insurance:			
Fire 11/	2,591	3,047	456
Liability 12/	820	1,075	255
Total	3,411	4,122	711
Total estimated annual ownership	184,238	214,769	30,531
Total estimated annual ownership per 1,000 cases shipped 13/	25.90	30.20	4.30

See following page for footnotes.

1/ Straight line method was used for calculations.

2/ Based on an estimated life of 30 years and no salvage value.

3/ Based on an estimated life of 10 years and no salvage value.

4/ Based on an estimated life of 7 years and 20-percent salvage value for the truck, 5-percent salvage value for the battery chargers.

5/ Simple interest method of calculations was used, and an interest rate of 8 percent was assumed, based on recommendations of a midwestern bank official.

6/ Includes repairs to building, paving, rail siding, and sprinkler system, and estimated to be 0.75 percent of initial costs.

7/ Based on estimated bulb life of 24,000 hours and replacement cost of $7 per bulb. No charge was made for fixture repair.

8/ Based on 0.25 percent of initial cost of pallet racks.

9/ Based on 1.5 percent of initial cost of lift truck, charger, and batteries.

10/ Estimated to be 100 mils per $1 on assessed value, based on 60 percent of costs for construction and land.

11/ Calculated using estimated ordinary rates based on 90 percent of the value of building and equipment. Value of contents assumed to be the same for both warehouses.

12/ Estimated to be $1 per 100 square feet of building.

13/ Based on 7,120,702 cases shipped annually.

Annual Operating Costs

To eliminate any difference in costs per order selecting, selection lines were assumed to be similar in layout and identical in length for both facilities. However, forklift operations would be different in the two facilities and, therefore, must be compared.

Time studies were conducted in the two grocery warehouses--one having a 32-, the other a 25-foot ceiling. Average distances were estimated for vertical and for horizontal forklift movement that was necessary to replenish rack reserve storage levels in both. Also, average distances were estimated for horizontal movement that was necessary to move products from the floor stack reserve storage to pallet racks in the low-ceiling facility. No estimates were made of the time involved in performing such tasks as hand-stacking cases (in the selection levels) or collecting empty pallets.

Results indicated that forklift operations would require 10,075 and 12,483 hours per year in the high-ceiling and in the low-ceiling facility, respectively (See Appendix, Part 2 (B.3a and C.3a) 2/ An average wage rate for forklift operators of $4.70 per hour was reported in a study currently being conducted by the Food Distribution Research Laboratory, Agricultural Marketing Research Institute. According to the primary cooperators, operators of the high-stacking forklifts are paid approximately $0.05 per hour more than operators of conventional forklifts.

2/ See Appendix, Part 2 for all calculations in this section. Letters and numbers in parentheses refer to the appropriate paragraph.

At a wage rate of $4.70 and $4.75 per hour in the low-ceiling and in the high-ceiling facility, respectively, the total labor costs for these operations amounted to approximately $58,670 ($4.70 x 12,483) and $47,857 ($4.75 x 10,075) per year in the low ceiling and in the high-ceiling facility, respectively (C.3b and B.3b). The difference was $10,813 per year in favor of the high-ceiling facility. On the basis of cost per 1,000 cases shipped, the annual labor cost for forklift operations amounted to $6.72 and $7.40 in the high-ceiling and in the low-ceiling facility, respectively (B.3c and C.3c).

Total Estimated Annual Ownership and Operating Costs

A summary of the total estimated annual ownership and operating costs is shown in table 4. Based on the analysis of the high-ceiling facility and the underlying assumptions (as listed in the Introduction), the estimated annual ownership and operating costs amounted to $232,095 and $273,439, respectively, for the high-ceiling and the low-ceiling facility--a difference of $41,344 per year (about 18 percent) in favor of the high-ceiling facility. On an annual basis, the cost of owning and operating the high-ceiling facility was $5.80 less per 1,000 cases shipped ($38.40 - $32.60) than that for the low-ceiling facility.

TABLE 4.--Total estimated annual ownership and operating costs for a high-ceiling and a low-ceiling grocery warehouse

Item	Cost with high-ceiling facility	Cost with low-ceiling facility	Savings with high-ceiling facility
	Dollars	Dollars	Dollars
Total estimated annual ownership 1/	184,238	214,769	30,531
Forklift operators 2/	47,857	58,670	10,813
Total estimated annual ownership and operating costs	232,095	273,439	41,344
Total estimated annual ownership and operating costs per 1,000 cases shipped 3/	32.60	38.40	5.80

1/ See table 3.
2/ See Appendix, part 2, for calculations.
3/ Based on 7,120,702 cases shipped annually.

Before deciding the ceiling height for new facilities, managers of grocery warehouses should make a precise, detailed comparison of the costs of owning and operating high-ceiling and low-ceiling facilities. The methodology should be similar to that used in this report. Managers of low-ceiling warehouses should use the actual operating data from their own facilities for the comparison, rather than the assumed data given in this report. However, they may use the assumed data for a high-ceiling facility.

APPENDIX 1

Assumptions Used for Estimating Time and Cost for Forklift Operations

To facilitate estimating costs for forklift and pallet jack operations in both facilities, the following assumptions were made:

A. The quantity of products received was equal to the quantity of products shipped.

B. Stock rotation in the high-ceiling facility was as follows: From receiving, to reserve storage (located in pallet racks), to selection fronts.

C. Stock rotation (based on percentage of reserve storage area in floor stacks and in pallet racks) in the low-ceiling facility was: From receiving, 45 percent of receipts to floor-stacked reserve storage, then to selection fronts; 55 percent of receipts to reserve storage (located in pallet racks), then to selection fronts.

D. Each forklift truck moved only one pallet per trip.

E. The average vertical distance that a forklift truck traveled was based on all possible combinations of pallet movement into and out of all pallet racks and all floor-stacked reserve.

F. The average horizontal distance that a forklift truck traveled was based on the distance from a designated starting point to the middle of the aisle and returning to the starting point. The following starting points were used:

   1. For forklifts in the high-ceiling facility, the starting point was the end of the aisle.

   2. For forklifts in the low-ceiling facility, the starting point for filling selection fronts from the overhead-racked reserve storage was the end of the aisle. For filling selection fronts from the floor-stacked reserve storage, the starting point was the middle of the floor-stacking aisles.

APPENDIX 2

Calculations Used for Estimating Time and Cost for Forklift Operations

A. The number of pallet loads of products shipped per year: 7,120,702 cases shipped per year ÷ 21 cases per pallet = 339,081 pallet loads of products shipped per year.

B. Forklift operations in high-ceiling facility.

1. Vertical movement:

    a. Letdown distance to fill selection fronts: 339,081 pallet loads per year to fill selection fronts x 13.08 feet (average pallet load letdown distance from racked reserve storage to selection fronts) = 4,435,180 feet per year for lowering and placing pallet loads in selection fronts in high-ceiling facility.

    b. Lifting distance to fill racked reserve storage fronts: 339,081 pallet loads per year x 19 feet per trip (average pallet load lifting distance from floor to racked reserve storage fronts) = 6,442,539 feet per year for lifting and placing pallet loads in racked reserve storage in high-ceiling facility.

    c. Total feet of vertical movement per year: 4,435,180 feet per year for lowering and placing pallet loads in selection fronts + 6,442,539 feet per year for lifting and placing pallet loads in racked reserve = 10,877,719 feet of total vertical movement per year in high-ceiling facility.

    d. Total time per year for vertical movement: 10,877,719 feet of total vertical movement per year ÷ 57 feet per minute (average vertical speed of forklifts) = 190,837 minutes per year for total vertical movement; 190,837 minutes per year for total vertical movement ÷ 60 minutes per hour = 3,181 hours per year of total vertical movement in high-ceiling facility.

    e. Total costs per year for vertical movement: 3,181 hours per year for total vertical movement in high-ceiling facility x $4.75 per hour for forklift operators = $15,110 labor cost per year for total vertical movement in high-ceiling facility.

2. Horizontal movement:

   a. Total number of trips per year:
   339,081 trips per year to fill selection fronts (one trip per pallet load) + 339,081 trips per year to fill racked reserve storage = 678,162 total number of trips per year to place pallet loads in selection fronts and in racked reserve storage fronts in high-ceiling facility.

   b. Total feet of horizontal movement per year:
   678,162 total number of trips per year x 330 feet per trip = 223,793,460 feet of total horizontal movement per year in high-ceiling facility.

   c. Total time per year for horizontal movement:
   223,793,460 feet of total horizontal movement per year ÷ 541 feet per minute (average speed of forklifts) = 413,666 minutes per year for horizontal movement; 413,666 minutes per year for horizontal movement ÷ 60 minutes per hour = 6,894 hours per year for total horizontal movement in high-ceiling facility.

   d. Total costs per year for horizontal movement:
   6,894 hours per year for total horizontal movement x $4.75 per hour for forklift operators = $32,747 labor cost per year for total horizontal movement in high-ceiling facility.

3. Total time and cost per year for forklift operations in high-ceiling facility:

   a. Total time:
   3,181 hours per year of total vertical movement + 6,894 hours per year of total horizontal movement = 10,075 hours per year of total forklift movement in high-ceiling facility.

   b. Total costs:
   $15,110 per year for total vertical movement + $32,747 per year for total horizontal movement = $47,857 per year labor cost for total forklift movement in high-ceiling facility.

   c. Total costs per 1,000 cases shipped:
   $47,857 per year cost for total forklift movement in high-ceiling facility ÷ 7,120,702 cases shipped per year = $0.00672 cost per case x 1,000 cases = $6.72 per 1,000 cases shipped for total movement cost in high-ceiling facility.

C. Forklift operations in low-ceiling facility.

1. Vertical movement:

   a. Letdown distance to fill selection fronts from racked reserve storage:
   186,495 pallet loads per year to fill selection fronts x 10

feet (average distance from racked reserve storage to selection fronts) = 1,864,950 feet per year for lowering and placing pallet loads in selection fronts in low-ceiling facility.

b. Lifting distance to fill selection fronts from floor-stacked reserve storage:
152,586 pallet loads per year x 3.25 feet per trip (average pallet load lifting distance from floor to selection fronts) = 495,905 feet per year to place pallet loads in selection fronts from floor-stacked reserve storage in low-ceiling facility.

c. Lifting distance to fill racked reserve storage fronts:
186,495 pallet loads per year x 15 feet per trip (average pallet load lifting distance from floor to racked reserve storage fronts) = 2,797,425 feet per year for lifting and placing pallet loads in racked reserve storage in low-ceiling facility.

d. Lifting and lowering distance to place and remove pallet loads from floor-stacked reserve storage:
152,586 pallet loads per year to place and remove products in floor-stacked reserve storage x 20 feet total (10-feet-average lifting distance + 10-feet-average lowering distance) = 3,051,720 feet per year for placing and removing pallet loads from floor-stacked reserve storage in low-ceiling facility.

e. Total feet of vertical movement per year:
1,864,950 feet per year for lowering and placing pallet loads in selection fronts from racked reserve storage + 495,905 feet per year for placing pallet loads in selection fronts from floor-stacked reserve storage + 2,797,425 feet per year for lifting and placing pallet loads in racked reserve storage fronts + 3,051,720 feet per year for placing and removing pallet loads from floor-stacked reserve storage = 8,210,000 feet of total vertical movement per year in low-ceiling facility.

f. Total time per year for vertical movement:
8,210,000 feet of vertical movement per year ÷ 57 feet per minute (average vertical speed of forklifts) = 144,035 minutes per year for total vertical movement; 144,035 minutes per year for total vertical movements ÷ 60 minutes per hour = 2,401 hours per year for total vertical movement in low-ceiling facility.

g. Total costs per year for vertical movement:
2,401 hours per year for total vertical movement in the low-ceiling facility x $4.70 per hour for forklift operators = $11,285 per year for total vertical movement in low-ceiling facility.

2. Horizontal movement:

   a. Total distance traveled to fill selection fronts from racked reserve storage:
      186,495 trips per year to fill selection fronts x 330 feet per trip = 61,543,350 feet of total horizontal distance traveled per year to fill selection fronts in low-ceiling facility.

   b. Total distance traveled to fill selection fronts from floor-stacked reserve storage:
      152,586 trips per year to fill selection fronts with pallet loads from floor-stacked reserve storage x 854 feet per trip = 130,308,444 feet of horizontal movement per year to fill selection fronts from floor-stacked reserve storage in low-ceiling facility.

   c. Total distance traveled to fill racked reserve storage:
      186,495 trips per year to place pallet loads of products in rack reserve storage x 330 feet per trip = 61,543,350 feet per year to fill racked reserve storage in low-ceiling facility.

   d. Total distance traveled to fill floor-stacked reserve storage:
      152,586 trips per year to place pallet loads in floor-stacked reserve storage x 484 feet per trip = 73,851,624 feet of horizontal movement per year to fill floor-stacked reserve storage in low-ceiling facility.

   e. Total feet of horizontal movement per year:
      61,543,350 feet of horizontal movement per year to fill selection fronts from racked reserve storage + 130,308,444 feet of horizontal movement per year to fill selection fronts from floor-stacked reserve storage + 61,543,350 feet of horizontal movement per year to fill racked reserve storage + 73,851,624 feet of horizontal movement per year to fill floor-stacked reserve storage = 327,246,768 feet per year of total horizontal movement in low-ceiling facility.

   f. Total time per year for horizontal movement:
      327,246,768 feet per year of total horizontal movement ÷ 541 feet per minute (average horizontal speed of forklifts) = 604,892 minutes per year for total horizontal movement; 604,892 minutes per year for total horizontal movement ÷ 60 minutes per hour = 10,082 hours per year for total horizontal movement in low-ceiling facility.

   g. Total cost per year for horizontal movement:
      10,082 hours per year for total horizontal movement x $4.70 per hour for forklift operators = $47,385 per year for total horizontal movement in low-ceiling facility.

3. Total time and cost per year for forklift operations in the low-ceiling facility:

   a. Total time:
   2,401 hours per year for total vertical movement + 10,082 hours per year for total horizontal movement = 12,483 hours per year for total forklift movement in low-ceiling facility.

   b. Total cost:
   $11,285 per year for total vertical movement + $47,385 per year for total horizontal movement = $58,670 per year for labor cost for total forklift movement in low-ceiling facility.

   c. Total cost per 1,000 cases shipped:
   $58,670 per year for total movement in low-ceiling facility ÷ 7,120,702 cases shipped per year = $0.00824 cost per case x 1,000 cases = $8.24 per 1,000 cases shipped for total movement cost in low-ceiling facility.

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